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STRESS RELAXATION OF INTERIM RESTORATIVES.(U)

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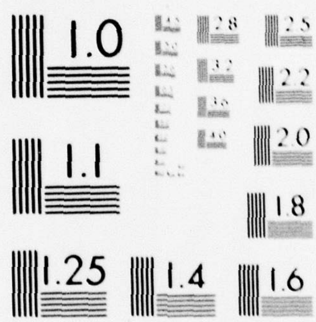

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Stress Relaxation of Interim Restoratives		5. TYPE OF REPORT & PERIOD COVERED Rept. for ~~Manuscript~~ 15 Nov 77-18 May 78
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) H. Stanley Maerki, Jr, Eugene F. Huget, Stanley G. Vermilyea [redacted] Laszlo B. de Simon		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Institute of Dental Research Walter Reed Army Medical Center Washington, D.C. 20012		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6033 (Project No.) 00119-6
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Medical Research and Development Command ATTN: (SGRD-RP) Fort Detrick, Maryland 21701		12. REPORT DATE 18 May 1978
		13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 12 13 p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

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DDC JUN 20 1978 F

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

interim restoratives; stress relaxation; endodontic sealers; dental materials, rheological behavior

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Stress relaxation of four temporary restoratives was studied. In the vicinity of ambient mouth temperature, the relaxation characteristics of an unmodified zinc oxide-eugenol cement were more favorable than those of IRM and Cavit. The plastic behavior of gutta-percha temporary stopping precluded assessment of its relaxation at temperatures in excess of 22P C.

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STRESS RELAXATION OF INTERIM RESTORATIVES

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Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the equipment and materials are necessarily the best available for the purpose.

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STRESS RELAXATION OF INTERIM RESTORATIVES

Several materials are available for the interim restoration (sealing) of endodontic access openings. The effectiveness of the materials in preventing the ingress and egress of salivary ions and bacteria is dependent upon numerous physical and mechanical factors. One such factor is stress relaxation, a gradual decrease in stress under a constant strain.

The paucity of information on the relaxation behavior of interim restoratives led to initiation of the present study.

Materials and Methods

Test materials included an unmodified zinc oxide-eugenol cement,[*] a resin reinforced zinc oxide-eugenol cement, IRM,[+] Cavit[§] and a gutta-percha temporary stopping.[#]

Slurries of the unmodified zinc oxide-eugenol cement were mixed using respective powder-liquid portions of 5 gm. and 1 ml.

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* Zinc oxide powder, Mallinckrodt Chemical Works, New Nork, NY; USP eugenol, Magnus, Mabee and Reynard, Inc., New York, NY.

\+ The L. D. Caulk Co., Milford, DE.

§ Premier Dental Products Co., Philadelphia, PA.

\# The Hygenic Dental Manufacturing Co., Phildelphia, PA.

The components of the resin reinforced cement were proportioned and mixed in accordance with its manufacturer's instructions. The cements were packed into 4 X 8 mm. cylindrical Teflon molds. Cavit was expressed from metal tubes and condensed into similar molds. Segments (~ 8 mm.) of gutta-percha were cut from rods that had diameters of about 4 mm. All specimens were stored at 37° C. and 100 percent relative humidity for 24 hours before further handling. The ends of the 24 hour-old test pieces were surfaced plane and perpendicular to their axes.

To determine the appropriate magnitude[¶] of applied stress for comparative assessment of the relaxation behavior of the test materials, the following procedure was employed. Six specimens of each material were subjected to compressive testing on a constant strain-rate testing machine.[Ω] Testing was conducted under ambient laboratory conditions (22±2° C. and 50±5% relative humidity) at a crosshead speed of 0.02 inch per minute. Elastic limits of the temporary restoratives estimated from load tracings ranged from 600 psi for gutta-percha to 2,900 psi for IRM. Stress-strain relationships indicated that a maximum stress of 400 psi could be applied transiently to 4 X 8 mm.-specimens of the test materials without inducing permanent deformation.

¶ Stress less than the elastic limit of any test material.

Ω Instron Universal Testing Machine, Instron Corp., Canton, MA.

Relaxation measurements were made within a constant temperature water bath at nominal temperatures of 11, 22, 30, 37, 45 and 56° C. Each specimen was compressed axially at a strain-rate of 0.02 inch per minute. When a stress (S_o) of 400 psi was attained, descent of the machine's crosshead was terminated. Subsequent relaxation of the test pieces yielded a measurable stress loss (D_t) with no change in strain. Stress was measured at 6-second intervals over a 60-second period. Six specimen-lots of each interim restorative were tested at each experimental temperature. To compensate for inherent error caused by relaxation of the testing machine, a relatively noncompressible 4 X 8 mm. stainless steel rod was exposed to the test procedure before and after the compression of three experimental cylinders. The resulting system-relaxation pattern was used to adjust (normalize) the experimental data.[1&2]

Results

Fractional stress loss (D_t/S_o) curves as a function of time at a specific test temperature are shown in Fig. 1. Fractional stress loss did not exhibit a linear relationship to time. However, plots of fractional stress loss versus ln (time + 1) were straight lines. The slopes of these lines defined the relaxation rates of the interim restoratives.

Relative relaxation rates of the test materials as a function of temperature are depicted in Fig. 2. Variations in relaxation rates over the experimental temperature range were complex. Relaxation rates for Cavit increased exponentially between temperatures of 11 to 37° C., but decreased exponentially at temperatures ranging from 37 to 56° C. The rate of stress relaxation exhibited by specimens formed from unmodified zinc oxide-eugenol cement was constant between 11 and 37° C., but exponential between 37 and 56° C. Relaxation rates of IRM were constant between 11 and 22° C. and between 37 and 45° C. However, the stress relaxation rates of the latter restorative varied linearly between relatively moderate temperatures of 22 to 37° C.

Above 22° C., gutta-percha deformed plastically upon the application of an external stress of 400 psi. Therefore, its relaxation over the entire range of experimental temperatures could not be measured.

Values for total stress loss at 60 seconds ($D_t/S_o/60$) for each material are given in the table. Stress losses for the unmodified zinc oxide-eugenol cement and for IRM tended to increase over the entire experimental temperature range. Stress losses for Cavit peaked within a relatively narrow temperature-band of 30 to 45° C.

Discussion

The interim restoration functions, in part, as a strained closure device. Mild, but relatively constant forces exerted against the walls of an access opening by such a device play a prominent role in development and maintenance of the so-called marginal seal. It follows, that excessive relaxation of a restoration during its exposure to transient masticatory stresses or to stresses induced by rapid cyclic temperature change would weaken the seal.

The abilities of restoratives to maintain an effective marginal seal vary widely.[3-6] Additionally, upon exposure to cyclic temperature change, some materials that perform well at normal mouth temperature allow increased permeation of the tooth-restoration phase boundary by dye[4] and microorganisms.[5] The aforementioned observations suggest that excessive internal stress differentials created by drastic experimental temperature change can contribute to the apparent failure of certain temporary restoratives.

Stress loss patterns of the materials examined in the present study reflect the effects of time, temperature, applied stress, applied strain and strain rate. From the data, it is clear that the materials exhibit subtle as well as marked differences in relaxation behavior. These differences would appear to be manifestations of compositional and structural features unique to each interim restorative.

In normal function transient temperature changes occur within the oral cavity. However, it is seldom that either the magnitude or the duration of change is sufficient to provoke marked alteration of the ambient temperatures of nonmetallic temporary restoratives. At or near normal mouth temperature, the relaxation response of unmodified zinc oxide-eugenol cement is significantly less than the responses of IRM and Cavit. Therefore, with respect to relaxation behavior, the clinical capability of zinc oxide-eugenol cement to maintain an effective marginal seal would be expected to exceed the capability of either IRM or Cavit.

It must be pointed out that stress relaxation behavior can not be used as the sole criterion for selection of a specific material for clinical application. However, realization of the degree to which relaxation may occur is essential to the rational management of endodontically involved teeth.

Summary

Stress relaxation of four temporary restoratives was studied. In the vicinity of ambient mouth temperature, the relaxation characteristics of an unmodified zinc oxide-eugenol cement were more favorable than those of IRM and Cavit. The plastic behavior of gutta-percha temporary stopping precluded assessment of its relaxation at temperatures in excess of 22° C.

Legends for Figures

Fig. 1. Typical fractional stress loss curves of interim restoratives. Experimental temperature was 22° C.

Fig. 2. Relative relaxation rates of interim restoratives.

TABLE

STRESS LOSSES AT 60 SECONDS ($D_t/S_o/60$) FOR INTERIM RESTORATIVES

Material	Temperature, C					
	11	22	30	37	45	56
	%	%	%	%	%	%
Zinc Oxide-Eugenol Cement	9(1)*	13(2)*	11(3)*	15(2)*	18(1)*	19(4)*
IRM	11(2)	12(2)	16(2)	22(3)	22(3)	32(7)
Cavit	9(1)	13(3)	25(6)	25(2)	27(4)	19(4)
Gutta-Percha	24(3)	31(1)	--	--	--	--

* Means with standard deviations in parentheses.

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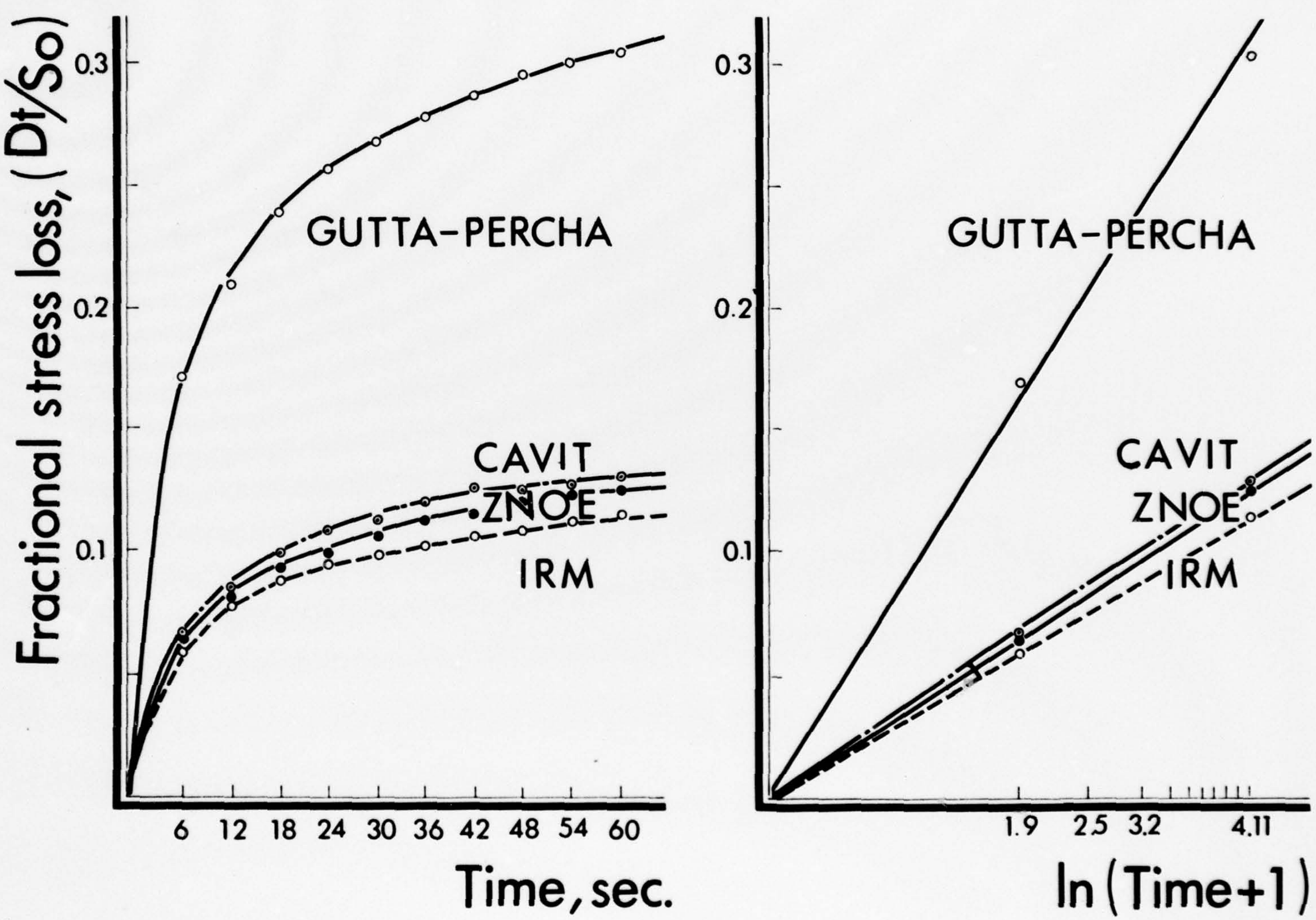
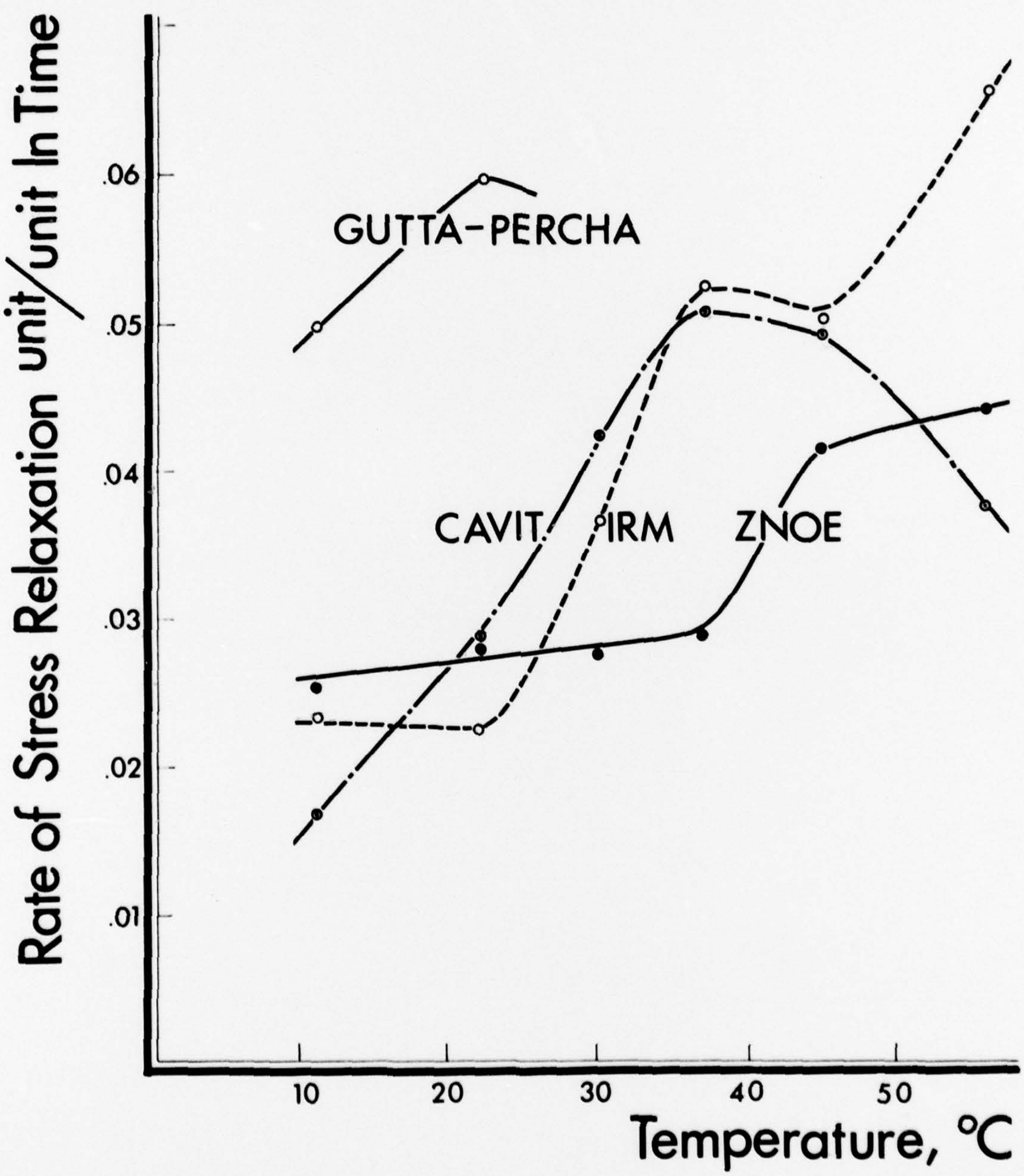


Fractional stress loss, (Dt/So)
0.1
0.2
0.3
GUTTA-PERCHA
CAVIT
ZNOE
IRM
6 12 18 24 30 36 42 48 54 60
Time, sec.
0.1
0.2
0.3
GUTTA-PERCHA
CAVIT
ZNOE
IRM
1.9 2.5 3.2 4.11
ln (Time+1)



Rate of Stress Relaxation unit/unit In Time
.06
.05
.04
.03
.02
.01
GUTTA-PERCHA
CAVIT
IRM
ZNOE
10
20
30
40
50
Temperature, °C